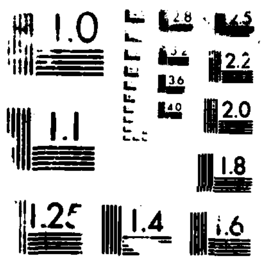
AD-A188 715   A PYROTECHNIC DELAY IGNITION SYSTEM FOR A SUBMARINE   1/1
LAUNCHED MARINE SIGNAL(U) MATERIALS RESEARCH LABS ASCOT
VALE (AUSTRALIA) B W WHIFFEN SEP 87 MRL-R-1079
UNCLASSIFIED   DODA-AR-005-170   F/G 19/1   NL

END
DATE FILMED
3 88
DTIC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

(4)

MRL-R-1079

AR-005-170

DTIC FILE COPY

DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

MATERIALS RESEARCH LABORATORIES

MELBOURNE, VICTORIA

AD-A188 715

REPORT

MRL-R-1079

A PYROTECHNIC DELAY IGNITION SYSTEM FOR A SUBMARINE LAUNCHED MARINE SIGNAL

B.W. Whiffen

Approved for Public Release

DSTO MRL
MARIBYRNONG

88 1 20 034

SEPTEMBER 1987

DEPARTMENT OF DEFENCE

MATERIALS RESEARCH LABORATORIES

REPORT

MRL-R-1079

A PYROTECHNIC DELAY IGNITION SYSTEM FOR A SUBMARINE LAUNCHED MARINE SIGNAL

B.W. Whiffen

ABSTRACT

This report describes the development of a delay ignition system for a submarine launched marine signal. The igniter, which incorporates a pyrotechnic delay element, was designed to transfer ignition from the payload expelling charge to the flare candle. The design eliminates ignition failures caused by water plumes extinguishing the igniters as the flare payload assembly is ejected from the signal canister.

Approved for Public Release

POSTAL ADDRESS: Director, Materials Research Laboratories
P.O. Box 50, Ascot Vale, Victoria 3032, Australia

CONTENTS

Page No.

1. INTRODUCTION 1

2. OPERATION OF SIGNAL 1

3. DEVELOPMENT 2

3.1 Experimental Delay System 2
3.2 Delay Ignition System 2

3.2.1 Redesign 2
3.2.2 Ignition Protection System 3
3.2.3 Delay Element 3
3.2.4 Ignition Transfer 4

3.3 Results of Firings 4

3.3.1 Static 4
3.3.2 Dynamic testing 5

4. CONCLUSIONS 6

5. ACKNOWLEDGEMENTS 6

6. REFERENCES 7

APPENDIX A *Pyrotechnic Composition used in Initial Delay Igniter*

APPENDIX B *Pyrotechnic Compositions used in Delay Igniter*

APPENDIX C *Technical Specifications - Pyrotechnic Delay Ignition System for Submarine Launched Marine Signal*

A PYROTECHNIC DELAY IGNITION SYSTEM FOR A SUBMARINE LAUNCHED MARINE SIGNAL

1. INTRODUCTION

Materials Research Laboratories was requested by the Australian Navy (NAV 83/137) to develop a submarine launched, parachute deployed marine signal. The operational requirements were for a signal with an extended viewing range capable of being launched in high sea state conditions. Existing service marine signals do not meet these requirements.

Explosives Materials Group was tasked to design a pyrotechnic delay igniter for the flare payload system. The delay igniter was required to:

(a) produce a nominal time interval of 6.0 s

(b) have a maximum length of 20 mm

2. OPERATION OF SIGNAL

The Marine Signal (Fig. 1) was designed to be launched from a submarine at a maximum depth of 310 metres and to float to the surface where a propellant charge would eject the flare payload from the signal canister [1]. The flare payload assembly (Fig. 2) contains the flare candle, parachute and the delay igniters, which are duplicated to improve reliability. The delay igniters which are ignited by the propellant charge combustion products allow the payload to reach a height of approximately 165 metres before flare ignition and parachute deployment occurs. When the flare payload approaches its apogee (165 metres), the delay igniters transfer ignition to the priming layer of the flare. This priming composition produces enough gas to deploy the parachute and flare candle from the payload tube.

3. DEVELOPMENT

3.1 Experimental Delay System

The design requirements for the delay system limited the choice of pyrotechnic compositions. Two compositions, SR 252 and SR 108 (Appendix A) were selected for the initial investigation because their performance was well documented [2]. Composition SR 108 was modified by adjusting the ingredient proportions to give a slower burning rate, enabling delay interval and dimensional requirements to be satisfied. The delay units were prepared by consolidating the composition into an ICI No 8 detonator tube at 150MPa. A sketch of these units can be seen in Fig. 3.

The experimental delay igniters produced time intervals of 6.0 ± 0.2 s when submitted to static testing, but during dynamic testing of the signal from a water filled tank (Fig. 4), the flare payload had passed through its apogee and was commencing free-fall before the parachute was deployed. For the parachute to be deployed before the flare payload had passed through its apogee, it would have been necessary to adjust the functioning time of the igniter back to approximately 4.5 s (statically measured). There also was an unacceptably high variation in the dynamic functioning times of the delay system with the observed spread being 1-2 s. A number of ignition failures of the delay unit also occurred during the dynamic testing. Analysis using high speed photography, of these tests showed a plume of water following and in contact with the flare payload for approximately 150 ms after the payload had cleared the floating signal cannister (Fig. 5). Inspection of the recovered delay units confirmed that they had been extinguished by water soon after payload assembly ejection.

To overcome these problems, the experimental delay igniter was completely redesigned. The use of mechanical methods such as shutters and baffles to protect the delay igniter from water ingression were considered unnecessarily complex and expensive. Therefore further development work to overcome these problems using pyrotechnics technology was undertaken.

3.2 Delay Ignition System

3.2.1 Redesign

Dynamic testing revealed problems in other sub-assemblies which had an adverse effect on the performance reliability of the marine signal. Design changes made to the propellant cartridge [3] and the flare payload base [4] to improve their performance benefited the redesign of the delay igniter by enabling the length of the delay tube to be increased from 20 mm to 30 mm. The increased length permitted a wider range of delay compositions to be considered. All pyrotechnic compositions used in the experimental delay system were rejected as they could not meet the time and dimensional requirements. The redesigned delay igniter consisted of a more robust delay tube which contained four pyrotechnic compositions, each chosen to perform a specific function (Fig. 6).

3.2.2 Ignition Protection System

Sulphur free gunpowder, grade 90 (SFG 90) was chosen as the ignition composition because of its ability to be readily ignited by the hot gases and particles produced by the payload expulsion charge. Although standard gunpowder has similar ignition properties to SFG 90, it was rejected because compatibility problems can arise under extended storage conditions. Performance degradation of standard gunpowder filled stores has been associated with the gunpowder reacting with metals and/or pyrotechnic oxidants that may be present in the store [5]. The perforation in the pellet of SFG 90 facilitated the rapid transfer of the burning front to the pressed column of SR 43 (Appendix B). The combination of a small column diameter and rapid burning rate of SR 43 afforded a high degree of protection to the delay composition by producing a gas jet capable of excluding the water plume. The length of consolidated SR 43, fixed at 10 mm, produced a gas jet for 300 ms, thus ensuring that the payload canister would be well clear of the water plume before the main delay was ignited.

3.2.3 Delay Element

The selection of the delay composition, SR 651 (Appendix B) for use in the delay element overcame the problem of delay time variation.

SR 651, having been developed for direct ignition from a propellant charge [2], is a physically strong composition when consolidated and its burning rate closely matches the requirements for the delay igniter. Its burning rate was known to vary with pressing load [6], therefore a series of tests was carried out to determine the optimum pressing load for the delay element. The results are shown in Table 1.

TABLE 1

Pressing load (MPa)	Mean Delay Length of SR 651 (mm)	Mean Delay Time (s)	Reciprocal Burning Rate (s/cm)
150	13.95	4.45	3.19
230	13.90	4.72	3.39
300	13.37	4.80	3.59
350*	-	-	-

* At a pressure of 350 MPa the aluminium delay tube deforms.

Using these results, a number of delay tubes were filled with SR 651 and consolidated at 300 MPa. After consolidation and cut-back the main delay element length was 13.2 mm. These units produced reliable delay intervals of 4.5 s - 4.6 s.

3.2.4 Ignition Transfer

The main delay composition SR 651, would not reliably ignite the flare priming layer across the small air gap in the payload base (Fig. 2). To overcome this problem the fast-burning igniter composition SR 41 (Appendix B) was included to transfer ignition from the main delay element to the flare priming layer. Granulated SR 41 was loose filled into the delay igniter and sealed by a frangible aluminium disc.

3.3 Results of Firings

3.3.1 Static

A number of delay igniters were statically fired after conditioning for one hour at +60°C, ambient and -40°C. The delay times were measured using the apparatus shown in Fig. 7. The results are listed in Table 2.

TABLE 2

Delay Igniter Static Test Results

Temperature (°C)	SR 651 Delay Length* (mm)	Mean Delay Time (s)	No of Tests
+60	13.20 ± 0.01	4.53 ± 0.07	10
ambient	13.15 ± 0.12	4.62 ± 0.08	15
-40	13.19 ± 0.02	4.77 ± 0.05	10

*All units filled as shown in Fig. 6.

The results show a typical trend of an increase in delay time with a decrease in temperature.

3.3.2 Dynamic testing

Dynamic tests were conducted from both the field test rig (Fig. 4) and a submarine 60 metres below the surface. The field test rig consisted of a large water filled drum and a marine signal simulator (Fig.8) loaded with the payload assembly containing either the flare candle or an inert substitute. The full marine signal (Fig. 1) was tested from a submarine only. A total of 27 delay ignition systems were prepared and fired. The results are listed in Table 3. Several parachute deployment failures were observed in the first series of tests. Inspection of the recovered test payload assembly showed that the delay units had failed to ignite. This was caused by a misalignment of the radiation hazard plate which is located between the propellant pan and the payload assembly [3]. The plate was modified and no further delay system failures occurred.

A performance specification of the marine signal delay system is included in Appendix C.

TABLE 3

Delay Igniter Dynamic Test Results

No of Shots	Payload Configuration	Results/Comments
	Dynamic Test Rig Launched	
4(8)*	Full payload assembly (Fig. 2)	All payloads deployed. 2 separate delay igniters failed. Failures due to poor alignment of radiation hazard plate.
4(8)	Inert flare package	All delays units functioned.
8(16)	Inert flare package	All payloads deployed. Flight times of 5.2-5.7s.
5(10)	Inert flare package Full payload assembly	Delay system proof for submarine trial. 1 shot aborted due to leaking retaining ring seal.
	Submarine launched	
6(12)	Full signal package (Fig. 1)	All payloads deployed

* Delay igniters deployed in duplicate.

4. CONCLUSIONS

4.1 Using a combination of well documented pyrotechnic compositions and simple engineering techniques, a delay ignition system which conforms to all of the design requirements has been developed for a submarine launched marine signal. The system affords effective protection from being extinguished by water and can operate over a wide range of temperatures.

4.2 It is recommended that further development of this system be undertaken to produce an item suitable for production.

5. ACKNOWLEDGEMENTS

The author wishes to thank M.A. Wilson (EMG) for his advice and assistance; and P. Rimington (EDG) and M. Coxhead (Eng. Support) for their support.

6. REFERENCES

1. Ramsay, P. (1987). Development of a Submarine Launched, Parachute deployed Marine Signal. MRL report in production, Materials Research Laboratories, Melbourne, Victoria.

2. Cackett, J.C. (1971). The Properties of SR *Pyrotechnic Compositions*. Report RARDE-R-1/71, Royal Armament Research and Development Establishment, Fort Halstead, Kent. Confidential report.

3. Nanut, V. (1986). Development of a Propellant Driven Ejection System for a Marine Pyrotechnic Signal. Report MRL-R-1011, Materials Research Laboratories, Melbourne, Victoria.

4. Swinton, R. (1987). Compositions suitable for a Parachute deployed Marine Pyrotechnic Signal. MRL report in production, Materials Research Laboratories, Melbourne, Victoria.

5. Cackett, J.C. (1965). Monograph on Pyrotechnic Compositions, (RARDE Special Publication, Fort Halstead, Kent), pp 9-12. Restricted publication.

6. Williams, N.R. (1980). The Manufacture and Properties of SR 651, SR 652 and SR 653. Information Sheet RARDE-IS-15, Royal Armament Research and Development Establishment, Fort Halstead, Sevenoaks, Kent. Restricted.

APPENDIX A

PYROTECHNIC COMPOSITIONS USED IN INITIAL DELAY IGNITER

1. SR 252

Potassium nitrate	40%
Silicon	40%
Gunpowder, sulphurless mealed	20%

Safety Certificate No. F221B
Specification No. DEF STAN 07-5

2. SR 108 (mod)

Potassium nitrate	45%
Barium nitrate	15%
Lactose	40%

Reciprocal bench burning rate — 3.6 s/cm (lead encased)

Safety Certificate No. 910 (SR 108)

Specification No. CS 5376 (SR 108)

APPENDIX B

PYROTECHNIC COMPOSITIONS USED IN DELAY IGNITER

1. SR 43

Boron	50%
Potassium Nitrate	50%
Reciprocal bench burning rate	0.4 s/cm (lead encased)

Safety Certificate No. 1063
Specification No. TS 50,005

2. SR 651

Purpurin	30%
Barium Nitrate	18%
Potassium Nitrate	52%
Reciprocal bench burning rate	2.1 s/cm (lead encased)

Safety Certificate No. 1100
Specification No. TS 50118

3. SR 41

Boron	20%
Potassium Nitrate	70%
Silicon	10%

Safety Certificate No. 1057
Specification No. TS 50,006

4. Sulphur free gunpowder, grade 90 (SFG 90)

Potassium Nitrate	70%
Charcoal	30%

Safety Certificate No. 240A

APPENDIX C

TECHNICAL SPECIFICATIONS - PYROTECHNIC DELAY IGNITION SYSTEM

FOR SUBMARINE LAUNCHED MARINE SIGNAL

1. Delay times

Static	4.62 ± 0.08 sec
Dynamic	5.7 ± 0.2 sec

2. Explosive Filling (pressing loads)

SFG 90	-	0.14 g	(150 ± 10 MPa)
SR 43	-	0.08 g	(300 ± 10 MPa)
SR 651	-	lead encased, 5.8 mm diameter 2 x 9.0 mm lengths	(300 ± 10 MPa)
SR 41	-	0.030 g	(loose filled)

3. Additional Information

(a) Non-explosive components

(1) Delay tube - to MRL Drawing MMSL 84/64

(2) Aluminium closing disc - 10.0 mm diameter x .05 mm

(3) Closing disc adhesive - Loctite 695

(4) Sealing varnish - RD 1177

(b) Total weight (single filled unit) 8.0 g

(c) Nett explosive content 0.50 g

(d) *UN* Classification (delay ignition system only) 1.4 G

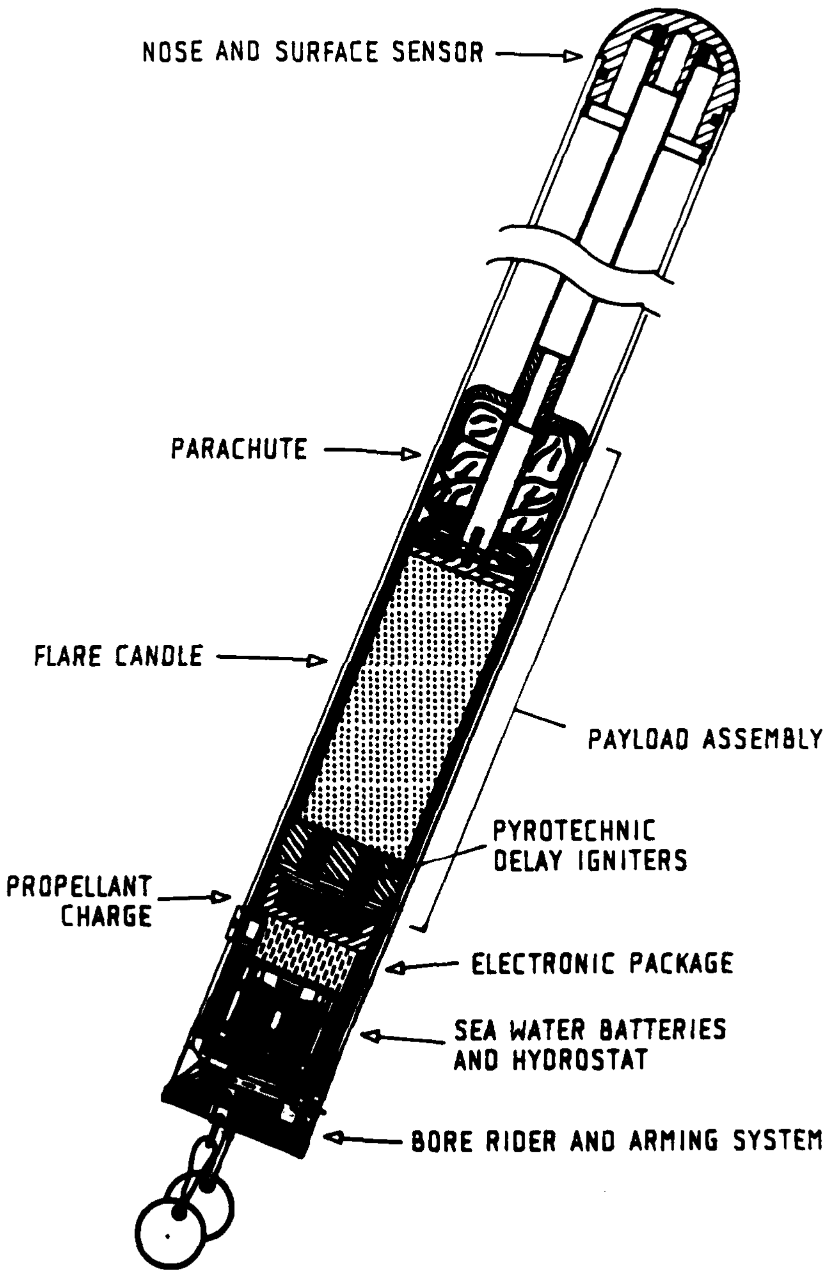


FIGURE 1 Marine signal-general arrangement.

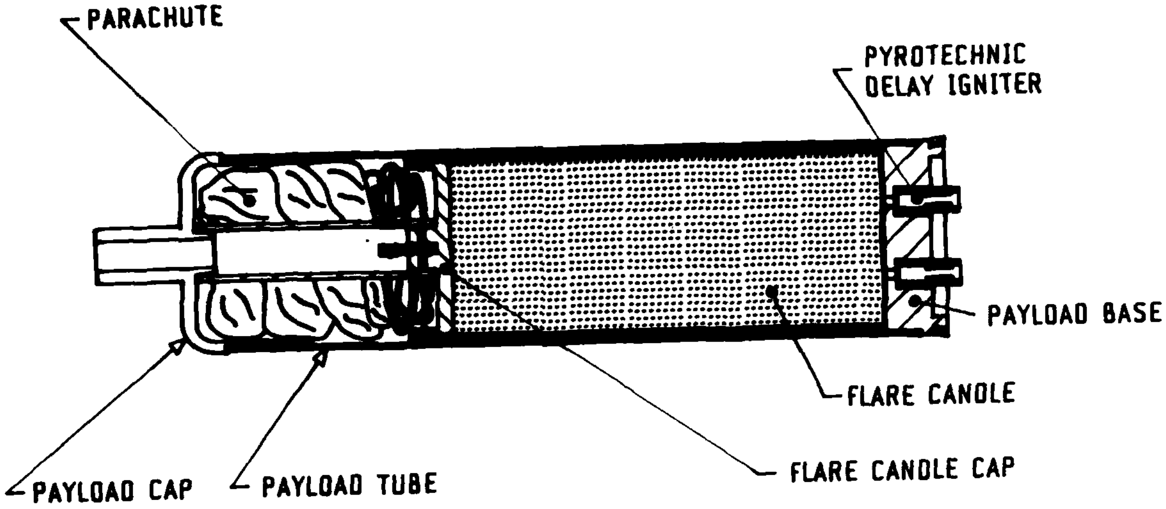


FIGURE 2   Flare payload assembly.

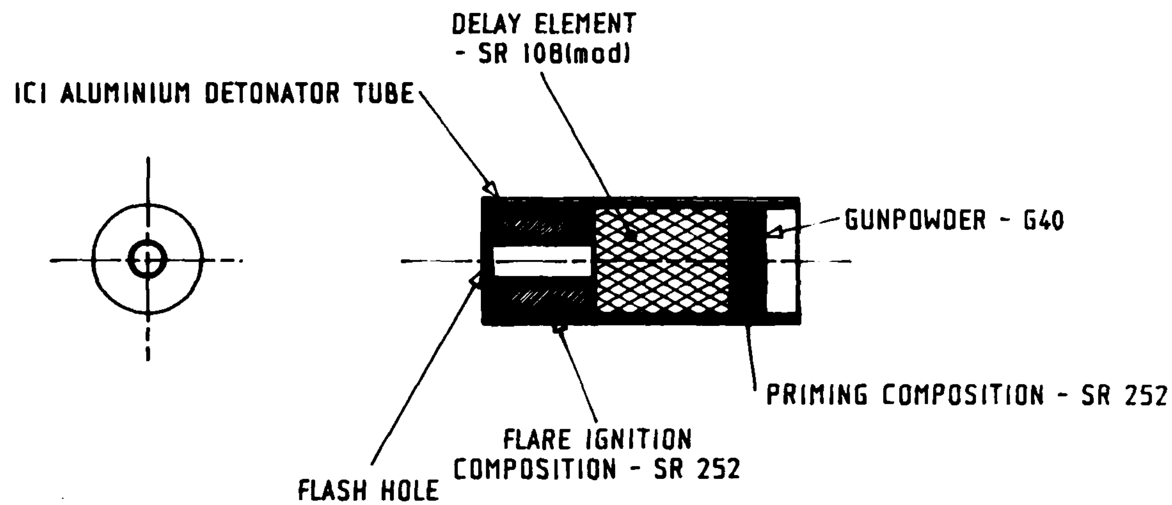


FIGURE 3   Experimental delay unit.

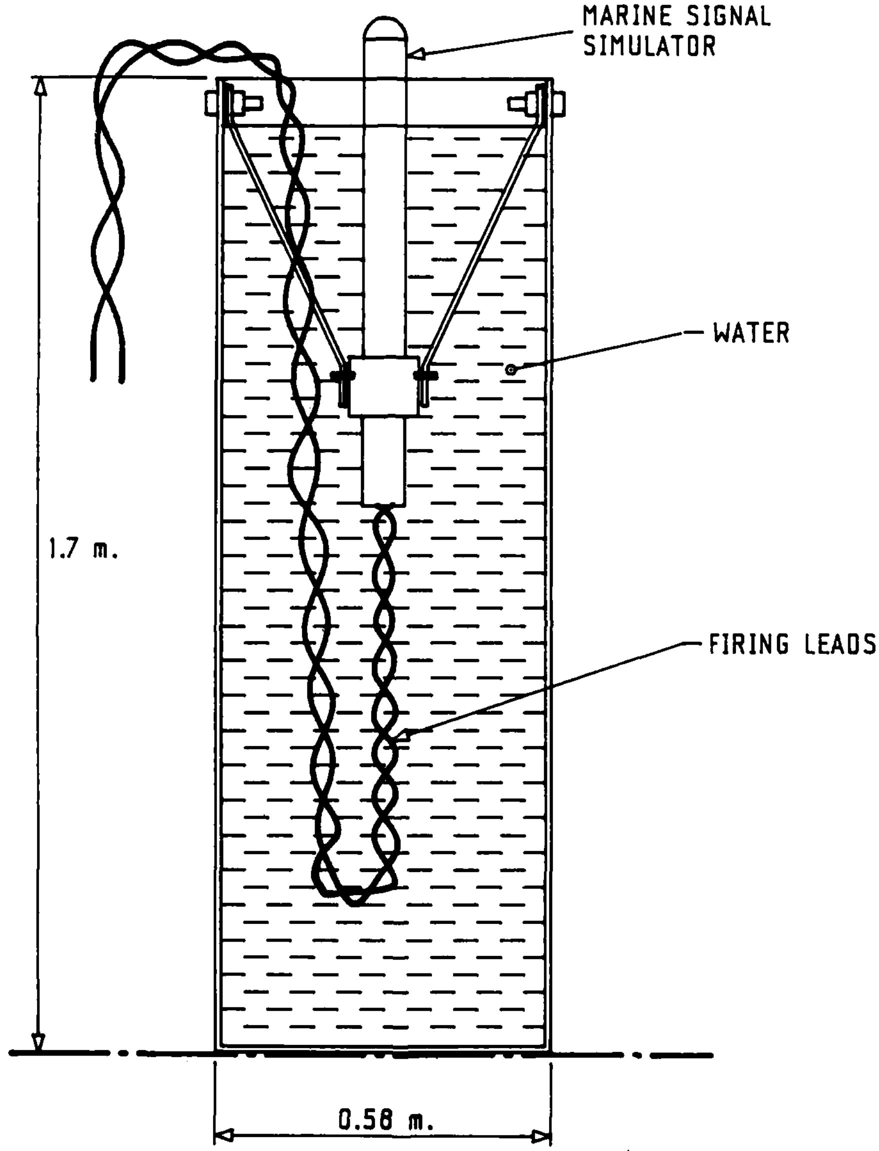


FIGURE 4 Field test rig.

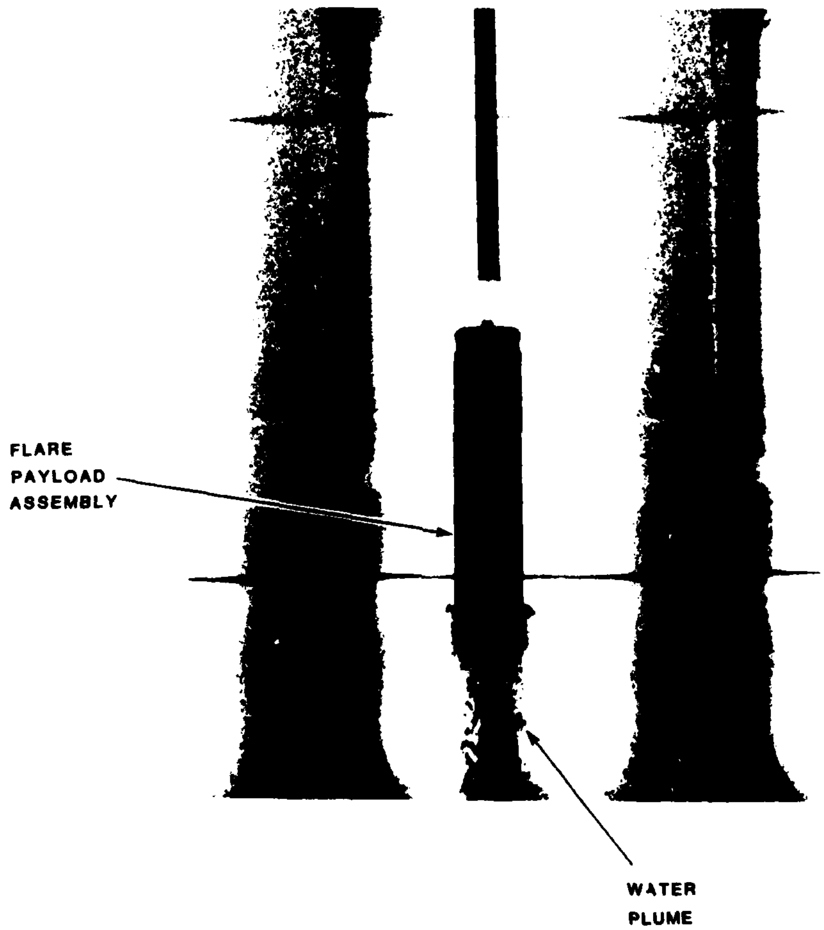


FIGURE 5 High speed photograph showing water plume and payload assembly interaction.

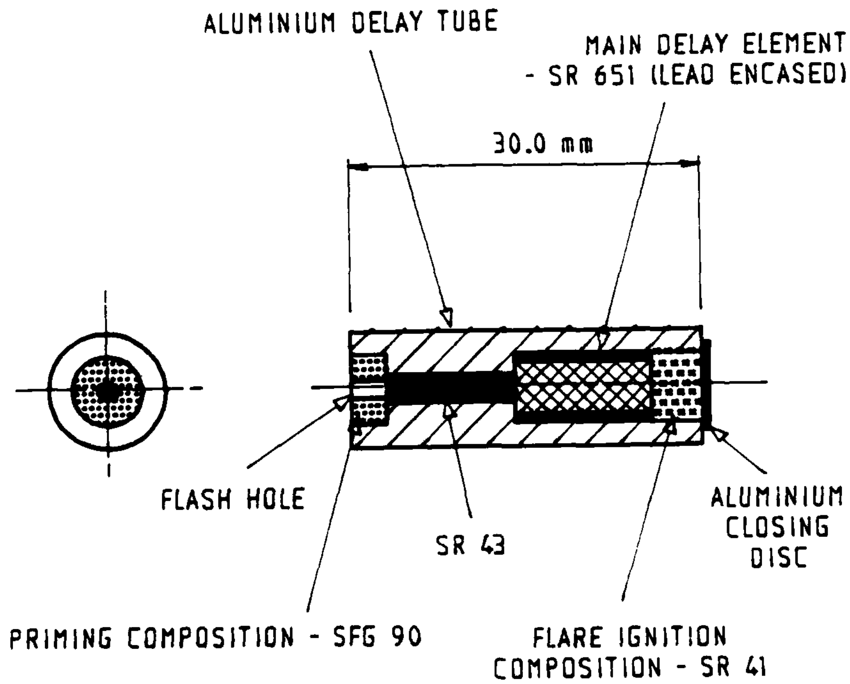


FIGURE 6 Delay igniter.

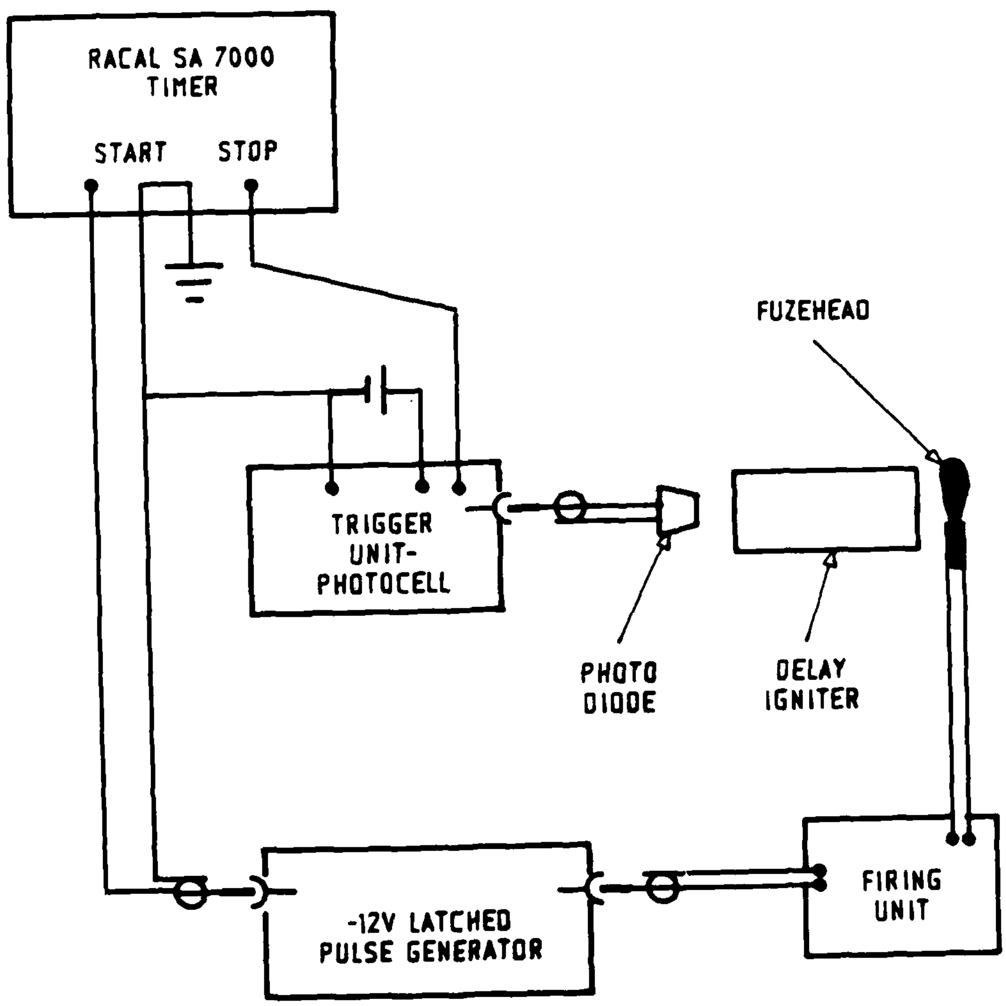


FIGURE 7 Static delay timing apparatus.

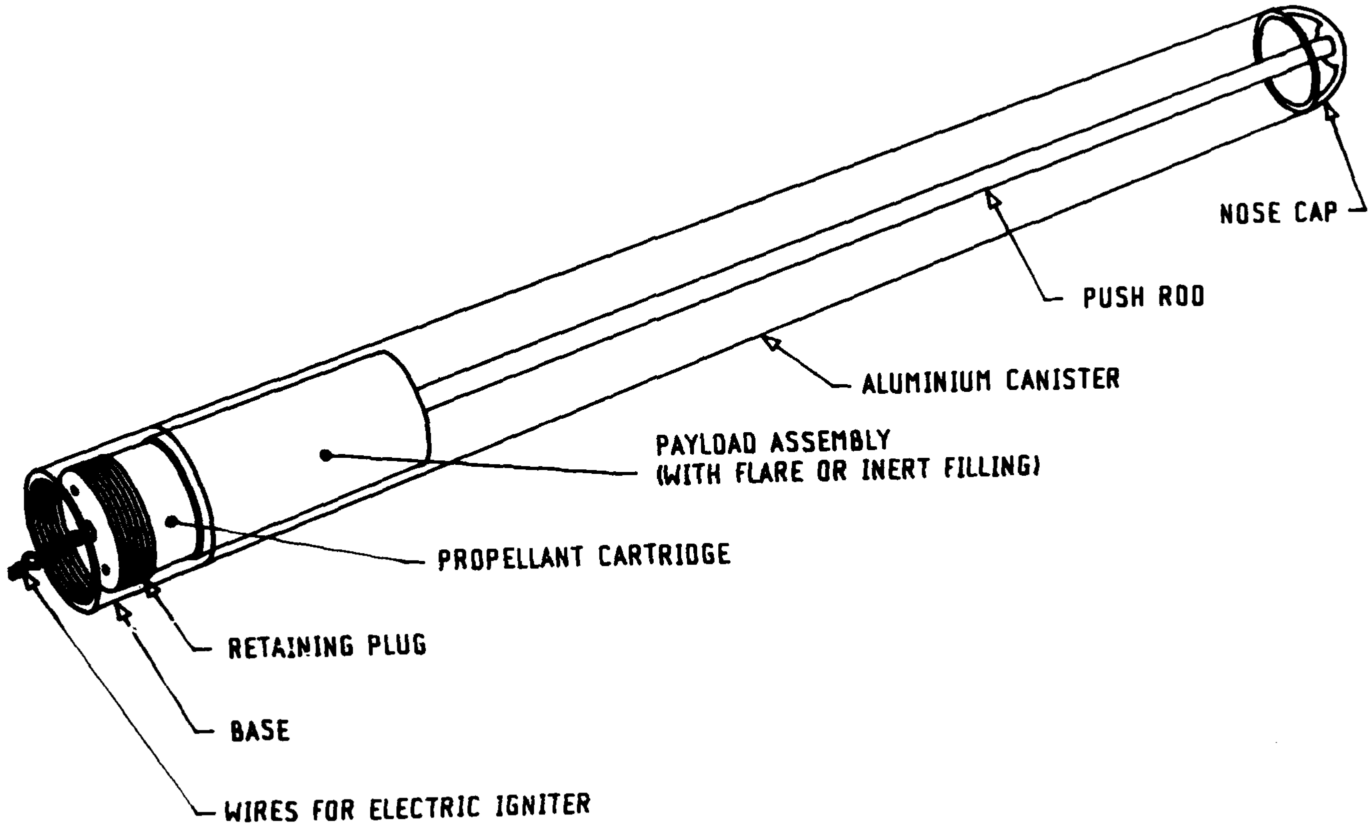


FIGURE 8 Marine signal simulator.

DOCUMENT CONTROL DATA SHEET

REPORT NO.	AR NO.	REPORT SECURITY CLASSIFICATION
MRL-R-1079	AR-005-170	Unclassified

TITLE

A pyrotechnic delay ignition system for a submarine launched marine signal

AUTHOR(S)

B.W. Whiffen

CORPORATE AUTHOR

Materials Research Laboratories
PO Box 50,
Ascot Vale, Victoria 3032

REPORT DATE	TASK NO.	SPONSOR
September 1987	NAV 85/137	Navy
FILE NO.	**REFERENCES**	**PAGES**
G6/4/8-3246	6	21

CLASSIFICATION/LIMITATION REVIEW DATE

CLASSIFICATION/RELEASE AUTHORITY
Superintendent, MRL
Physical Chemistry Division

SECONDARY DISTRIBUTION

Approved for Public Release

ANNOUNCEMENT

Announcement of this report is unlimited.

KEYWORDS

Submarine	Ignition systems	Signals
Pyrotechnic igniters	Ignition delay	

SUBJECT GROUPS 600 0079A

ABSTRACT

This report describes the development of a delay ignition system for a submarine launched marine signal. The igniter, which incorporates a pyrotechnic delay element, was designed to transfer ignition from the payload expelling charge to the flare candle. The design eliminates ignition failures caused by water plumes extinguishing the igniters as the flare payload assembly is ejected from the signal canister.

END

DATE

FILMED

3 88

DTIC